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Mathematics and Computers in Simulation 65 (2004) 351–363
MATHEMATICS AND COMPUTERS IN SIMULATION
www.elsevier.com/locate/matcom

Monte Carlo modeling of spin FETs controlled by spin–orbit interaction

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Abstract

A method for Monte Carlo simulation of 2D spin-polarized electron transport in III–V semiconductor heterojunction (FETs) is presented. In the simulation, the dynamics of the electrons in coordinate and momentum space is treated semiclassically. The density matrix description of the spin is incorporated in the Monte Carlo method to account for the spin polarization dynamics. The spin–orbit interaction in the spin FET leads to both coherent evolution and dephasing of the electron spin polarization. Spin-independent scattering mechanisms, including optical phonons, acoustic phonons and ionized impurities, are implemented in the simulation. The electric field is determined self-consistently from the charge distribution resulting from the electron motion. Description of the Monte Carlo scheme is given and simulation results are reported for temperatures in the range 77–300 K.

Keywords: Spintronics; Spin orbit; FET; Monte Carlo

1. Introduction

The Monte Carlo approach has been a widely used scheme for simulation of submicron or deep-submicron semiconductor devices. With given material properties of the semiconductor, it can account for non-equilibrium phenomena of charge carrier transport in the device channel and provide resolution beyond the drift-diffusion and hydrodynamic models. The step-wise simulation feature of the Monte Carlo approach makes it easier to incorporate different physics in the simulation [1] and avoids the assumptions needed in deriving alternative continuum drift-diffusion and hydrodynamic models [2,3]. It is because of this advantage that Monte Carlo simulation can also be used to provide the physical parameters required as the input data for drift-diffusion and hydrodynamic models.

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0378-4754/$30.00
doi:10.1016/j.matcom.2004.01.007